Detailed Study Plan for Coded Wire Tagging of Chinook Salmon in the Stanislaus River

Prepared for:

U.S. Department of Interior

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&
U.S. BUREAU OF RECLAMATION

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Summary

Beginning in 2007, United States Bureau of Reclamation (Reclamation) and United States Fish and Wildlife Service (FWS) will fund a five-year coded wire tag (CWT) study of juvenile fall Chinook salmon in the Stanislaus River. Reclamation is currently working to develop a Revised Plan of Operations (RPO) for New Melones Reservoir. One component of the RPO is to develop an instream fishery flow schedule; however, there is insufficient information to provide a basis for determining the timing and magnitude of flows needed for the outmigration of juveniles. The U.S. Fish and Wildlife Service (FWS) has provided a juvenile salmonid outmigration monitoring program in the Stanislaus River since 1995. The addition of complementary coded-wire tagging (CWT) of the juvenile population will assist the FWS' Anadromous Fish Restoration Program (AFRP) in evaluating the results of past and future habitat restoration and the population impacts of instream flow management.

The primary objectives of this project are to: 1) determine the relative contribution rates of fry, parr, and smolts to the returning adult population, 2) draw inferences on survival, growth and migration timing for juvenile salmonids in the Stanislaus River, San Joaquin River, and delta, 3) identify effects of differing flow schedules on salmonid production, and 4) make informed decisions when evaluating instream flow schedules for the Stanislaus River.

Methods will be used to ensure proper tag retention and minimal migratory disruption. Based on historic data, we anticipate annual sample sizes for coded-wire tagged juveniles of roughly 25,000 for the fry/parr life stages (35-70 mm) and 5,000 smolts (> 70 mm). The maximum annual tag-group size is unlikely to exceed 60,000 fry/parr and 10,000 smolts. A sub-sample (up to 3%) of tagged fish will be held for a 48-hour period to establish tag retention and mortality rates. The feasibility of holding the sub-sample group for longer periods (up to 6 days) will be investigated during the first season. Total mortality of all fish handled is expected to be less than 2%. Annual reports will summarize each year's sampling activities and detail the biological and physical data collected.

Introduction

Reclamation operates New Melones Dam and Reservoir on the Stanislaus River. These facilities regulate river flows in the lower Stanislaus River, which contains anadromous Chinook salmon and steelhead trout populations. Reclamation is currently working to develop a Revised Plan of Operations (RPO) for New Melones to "reduce the reliance on New Melones Reservoir for meeting water quality and fishery flow objectives, and to ensure that actions to enhance fisheries in the Stanislaus River are based on the best available science (P.L. 108-361)." One component of the RPO is to develop an instream fishery flow schedule; however, there is insufficient information to provide a basis for determining the timing and magnitude of flows needed for the outmigration of juveniles. The current management strategy focuses on increasing survival of smolts by providing increased flows in the late spring, though the population continues to decline under current operations. However, it is unknown whether juvenile salmonids that migrate earlier in the year as either fry or parr survive and return as adults to spawn. Additional monitoring is needed to determine the relative contribution to adult salmonid production by naturally produced fry, parr, and smolts in the Stanislaus River. By understanding the contribution rates of each size class (fry, parr, and smolts), the timing of spring flows may be designed to facilitate increased survival and production of juvenile salmonids in the Stanislaus River.

The U.S. Fish and Wildlife Service (FWS) has provided a juvenile salmonid outmigration monitoring program in the Stanislaus River since 1995. The monitoring program quantifies juvenile salmonid outmigration using rotary screw traps (RST) at Caswell State Park (13.8 Rkm). This long term data set provides a valuable source of information for evaluating fish response to in-river management actions and restoration activities through time. The addition of complementary coded-wire tagging (CWT) of the juvenile population will assist the FWS' Anadromous Fish Restoration Plan (AFRP) in evaluating the results of past and future habitat restoration and the population impacts of instream flow management.

The FWS contracted with Cramer Fish Sciences (CFS), with funding provided by Reclamation to conduct the five-year tagging study in tandem with existing juvenile outmigration studies at the Caswell site. In preparation for field sampling, and in response to requests to review the study plan, CFS produced this document to provide specific details regarding fish collection techniques and required permits, river access, sampling methods, data analysis, and final products.

This CWT study has four primary objectives:

- Determine the relative contribution rates of fry, parr, and smolts to the returning adult population.
- Draw inferences on survival, growth and migration timing for juvenile salmonids in the Stanislaus River, San Joaquin River, and delta.
- Identify effects of differing flow schedules on salmonid production.
- Make informed decisions when evaluating instream flow schedules for the Stanislaus River.

Scientific Collection and Incidental Take Permits

The sampling protocol, as described in this study plan, includes intensive fisheries monitoring during late winter and early spring in the Stanislaus River, where fall-type Chinook juveniles will be collected. Scientific collection permits will be required as part of the proposed investigations. The permits required to conduct the CWT study are listed in Table 1.

Table 1. Permits and agreements required for proposed work.

Permit/Agreement	Effective Date	Expiration Date
Individual Scientific Collectors Permit	All permits current	As early as 11/9/2006; as late as 5/1/2008
SCP Amendments	2006-07 monitoring	Need to apply annually

Property Access and Landowner Permission

The project site is located at the upstream end of Caswell State Park and can be accessed from the public campground. Since 1995, a verbal agreement has been in place between CFS and the State Park to use a campsite while field work is being done. Permits have been submitted to California State Parks to formalize this agreement and are pending. In the mean time, an agreement has been reached with an adjacent private landowner to install the tagging trailer and additional necessary equipment there.

Methods & Materials

This section describes the methods that Cramer Fish Sciences will employ during the capture, tag, and release of juvenile Chinook salmon. In brief, juvenile fall-type Chinook salmon will be collected at existing rotary screw traps, marked with half-length and sequential decimal CWTs, and adipose fin clipped. Multiple batches of unique tag codes will be used for fry and parr during each 7 day period, or for every 2,000 fish, whichever comes first. Smolt migrants will be marked with full-length sequential tags. Methods will be used to ensure proper tag retention and minimal migratory disruption, and will be based on similar projects conducted on Butte Creek by California Department of Fish and Game (CDFG) since 1995, and on the Mokelumne River by our staff during 2001 and 2002.

Anticipated survey periods are the same as rotary screw trap operations (January to July). The methods utilized in this survey combine techniques described primarily by Northwest Marine Technology (NMT 2003; Solomon 2005) and US Geological Survey's Columbia River Research Lab (CRRL 2006).

Collection of fish

Juvenile fall-run Chinook salmon will be collected using three rotary screw traps operating near Caswell (a third screw trap was installed this year) from January through July. The fish will be transported from the trap to the tagging trailer. With the addition of the third screw trap, no other trapping methods are being evaluated at this time. Starting January 2007, we anticipate that a total of 25,000 – 60,000 fry/parr between 35mm to 69mm fork length and 5,000 to 10,000 smolt of 70mm or greater will be tagged each year. Information on methods used in the rotary screw trap operations are provided in Addendum 1.

Tagging Trailer

A tagging trailer (Figure 1) will be set up immediately adjacent to the Caswell trap site location at the upstream end of Caswell State Park. The purpose of the trailer is to provide a semi-permanent location that will hold the equipment and material needed for tagging (power source, tag injector, needles, molds, tanks, pipes, pumps, aprons, nets, etc). Technical assistance will be provided by Big Eagle and Associates, who have extensive experience conducting CWT operations.

Figure 1. An example of a tagging trailer (Photo courtesy: Biomark, Inc)

Tagging

All tagging procedures will be conducted according to standard procedures recommended by Pacific Marine Fisheries Commission and Northwest Marine Technologies. Tagging will be accomplished using CWTs by means of a Mark IV Automatic Tag Injector (MKIV) (Figure 2). The MKIV is designed for large-scale projects involving tens of thousands of fish and is used to implant CWTs into the tissue of the fish (Figure 3). Due to the small size of the fry/parr, marking rates are expected to range from 400-500 fish per hour. A total of three MKIV devices will be used for this study.

Figure 2. Mark IV Automatic Tag Injector (Photo courtesy: NMT).

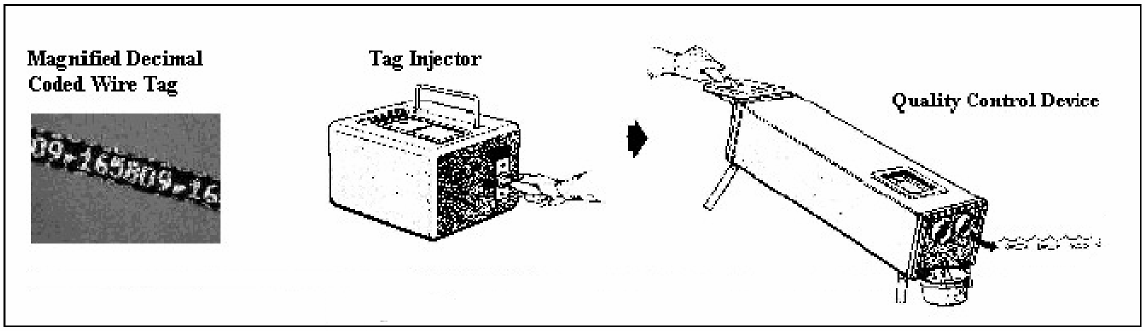


Figure 3. An overview of the tagging procedure (Source: NMT 2003).

A half-length tag format will be used for all fry/parr. Separate batch codes will be used for fry and parr. Batch codes will be changed every 7 days or every 2,000 marked fish, whichever comes first in February and March. For the remainder of the tagging season, fry and parr batch codes will be changed every 10 days, or every 2,000 marked fish, whichever comes first. By marking small groups of fish, CFS will be able to distinguish recoveries based on a limited time period of emigration. Differential contribution rates of the fry and parr life history types will be distinguishable and related to the environmental conditions during that migration period. Batch codes will also change annually.

Smolt migrants will be marked with full-length sequential tags. These tags will give each fish a unique mark and, relative to batch codes, allow for a more robust statistical interpretation of relationships between migration period, fish size, and environmental conditions. The design of this study allows us to determine the contribution rate of various life history types (fry, parr and smolt migrants) to the returning adult population and draw conclusions about the effects of a variety of environmental conditions (e.g., instream flow, turbidity, etc.) on contribution rate.

The tags will be batch coded with a two-digit Agency code (to identify the agency or region of origin) as well as four single-digit data codes (Agency, Data 1, Data 2, Data 3 and Data 4).

The tags will be implanted in the snout (Figure 5, area C), which is the most suitable implantation site for salmon. The snout area is relatively large and is some distance away from sensitive organs and tissue. A suitable implantation site is very critical to tag retention, fish health and tag recovery. Snout tagging will be done using a whole-head mold for the fry and parr, and a snout-only mold for the smolts. These molds are used to precisely position the fish during tagging (Figure 4). When tagging the fry and parr, the snout should fit easily into the mold without the eyes entering the interior portion of the head mold.

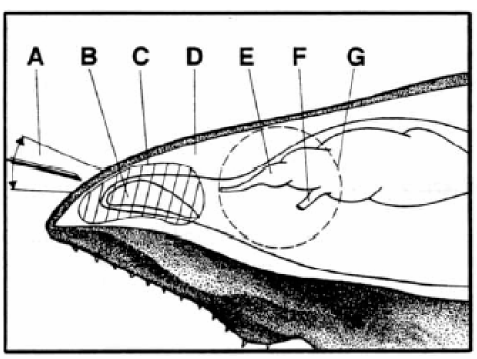
An etched needle will be used, because of its small size, compared to a non-etched needle. The etched needle is reduced to a smaller outside diameter from the beginning of the bevel, and is designed to make a smaller injection hole in the fish. This type of needle has been found to be very successful when used with head molds for Pacific salmon.

When a fish is ready to be tagged, its head will be inserted into the mold and the "tag" button depressed, a needle will penetrate the fish to a depth that is pre-set, the tag will be injected into the snout and the needle will subsequently be withdrawn. A sub-sample of fry/parr will be weighed and measured, and all smolts will be weighed and measured. Every fry/parr and smolt will be adipose fin-clipped to identify the presence of a CWT.

Tagging Quality Assurance/Quality Control

In order to ensure correct tag placement, 1 to 2 fish per day will be sacrificed and an experienced tagging operator will examine the tags' location in the snout. A small scalpel will be used to cut parallel to the needle hole back to the eyes. The scalpel blade will then be twisted slightly in order to reveal the inner section of the snout. Properly placed tags will appear in the center of the triangular shaped connective tissue within the snout.

In the event the tag is not properly placed, the tag injector (Mark IV) will be adjusted. To minimize sacrificing wild Chinook, any juveniles that have died as a result of trapping or handling will be used to assess correct tag placement (personnel will also be instructed to keep and freeze additional mortalities for future use).



A – Usual range of tagging needle angles
B – Muscle, adipose and fibrous tissue
C – Tag target area (hatched)
D – Cartilage
E – Olfactory lobe and nerve
F – Optic nerve
G – Position of eye

Figure 5. Typical Tag Placement for Salmonids (Source: NMT 2003).

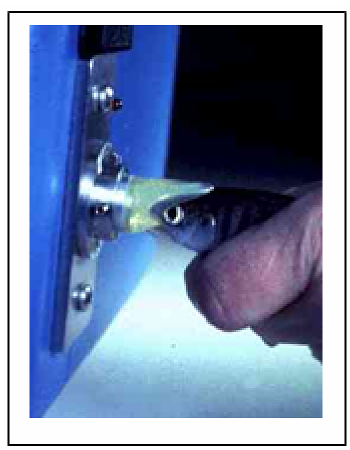


Figure 4. Mark IV fitted with a head mold for snout tagging (Photo courtesy: NMT).

A portable quality control device (T4 Detector) will be used to verify tag presence. Once the fish has been tagged, it is passed through the detector and when a CWT is detected, a gate opens, separating tagged and untagged fish.

Data Collection & Reporting

Daily batch records will be collected and will include the line and batch numbers, start and end of the counter reading, and batch data (Figure 6).

Project:______________________________ Date:____________

Personnel:______________________________ Sheet # _____of ______

Agency:______________________________

Notes:______________________________

Line #	Batch #	Counter reading		No. in batch	Batch data
		Start	End		

Figure 6. Storage sheet for batch identification

Once the tag group has been entirely processed, a CWT release report will be sent to Robert Kano, CWT program coordinator for CDFG. See Addendum 2 for a copy of the form.

Holding

The following describes the holding and release procedures used to ensure the health and survival of juvenile Chinook before and after tagging.

Pre-Tagging

Prior to tagging, fish will be transported from the collection site into the trailer's internal holding tank. The holding tanks will be supplied with fresh river water, and water chemistry (e.g., dissolved oxygen, temperature, etc) and flow levels will be monitored periodically throughout the day. Pre-tagging densities will be established using the following equation: mean fish weight (g) times the number of fish per liter of water in holding tank, where g/L does not exceed 20. Collection date and time will be recorded on the pre-tag holding container.

Post-Tagging

Recovery tanks will be prepared and monitored in the same manner as the holding tanks. We will maintain dissolved oxygen at saturation with daily periodic spot checks of percent saturation to insure oxygen flow rates are at acceptable oxygen saturation levels. If levels drop below 95% saturation, an oxygen bubbler will be added. Fresh river water will constantly be circulating through the trailer during the tagging operation and temperature will be constantly monitored.

Anesthetizing

As each batch of fish is prepared for tagging, they will be anesthetized in MS-222 in order to prevent them from struggling and to protect them from potential damage while they are being tagged.

To prevent potentially lethal doses of anesthesia in the tanks, the tagger will be the only person to prepare the anesthesia prior to tagging. A concentration of 26.4 mg/L will be used, which is the concentration used by Big Eagle and Associates for anesthetizing juvenile salmonids. However, the effectiveness of MS-222 as an anesthesia varies with factors such as temperature and fish density, and will therefore be adjusted accordingly when the actual tagging takes place.

Adjustment of the anesthesia concentration will be based on the amount of time it takes for a group of fish to lose equilibrium. Induction time will not be less than 1 minute and will not exceed 5 minutes. If it is determined that the induction time is outside of the acceptable range, the concentration of the anesthetic will be adjusted. The MS-222 concentration will never exceed 70 mg/L. The concentration used will be noted on the tagging data sheet. Equal amounts of Bicarbonate solution and MS-222 will be used in the anesthesia tanks.

When tagging is ready to proceed, the fish will be netted from the holding tanks and placed directly into the anesthesia bucket. No more than 25 fish will be placed in the anesthesia bucket at one time. As soon as a fish loses equilibrium, it will gently be taken by hand (while kept submerged) and examined more closely for external tags, fin clips, descaling, injuries, or signs of disease. If the fish is deemed unsuitable for tagging or if it has been in the anesthesia bucket for more than 5 min, the fish will be placed in a designated reject tank to recover. If the fish is suitable for tagging, it will gently be weighed, measured and have its adipose fin removed.

All equipment and countertops will be cleaned with ethyl alcohol (70% solution). Reject and anesthesia buckets will be rinsed with river water thoroughly and placed upside down to dry. In addition, all buckets will be cleaned weekly.

Monitoring Tag Retention and Mortality Rates

Sub-samples of tagged fish will need to be held to monitor mortality rates associated with the tagging process as well as for tag retention rates. Due to significant variation in daily catch rates at the Caswell trap, survival and tag retention estimates will occur only on days when a significant number of fish are captured. We estimate that 100 fish per 3,000 tagged fish should be removed and monitored for a minimum of a 48-hour period. Similar projects have had limited success holding wild fish for more than a few days as wild fish are more likely to suffer mortality as a result of being held. In the first year, we intend to explore the feasibility of holding fish for longer periods (up to 6 days) and will design the following years' retention studies based on those results.

Mortality resulting from the capture and tagging of juveniles will be less than 2% of the total number of fish. Tags recovered from mortalities will be returned to the tag coordinator.

Release

Following tagging, the fish will be held until deemed to be fully recovered from the effects of anesthesia (24 hours or less) and then returned to the river immediately downstream of their capture location, with the exception of the sub-sample group described earlier. Every effort will be made to release fish at night to minimize predation. Mortalities will be documented in the release report as will fish with shed tags.

Tag Recovery

Estimates for tag recovery rates are discussed below in the Sample Size and Analysis section. Data for both juvenile and adult coded-wire tag recoveries will be obtained from:

- DFG Central Valley spawning ground carcass surveys
- Interagency Ecological Program (IEP) trawl and seine data
- Pumping salvage
- DFG Mossdale trawls
- Pacific States Marine Fisheries Commissions' RMIS database,
- Central Valley salmon and steelhead in-river harvest and monitoring program (starting 2007)

Sampling programs in California are designed to sample at least 20% of the Chinook landed in ocean troll and recreational fisheries. Sampling CWT inland salmon in California occurs through a systematic creel survey on the Klamath-Trinity Rivers and sporadic sampling of fisheries in the Sacramento and San Joaquin basin. In-river CWT recoveries are also obtained from hatchery returns and spawning ground surveys. We estimate the majority of CWT recoveries in the Stanislaus River will occur during annual spawning ground surveys conducted by DFG.

Regional coordination of various tagging programs is provided by the Regional Mark Processing Center, which is operated by the Pacific States Marine Fisheries Commission. This center also maintains a centralized database for coast-wide CWT releases and recoveries, as well as for associated catch and sample data. CWT data are provided to users via interactive on-line data retrieval. For further information on recovery processes, please review information given by the Regional Mark Processing Center (www.rmpc.org).

Quality Assurance/Quality Control

A quality assurance/quality control program (QA/QC) will ensure the tagging staff is properly trained, the juvenile salmon are captured, tagged, and released in a way that minimizes stress and mortality, and accurate records of the tagging operations are kept.

Staff Training & Supervision

Staff training and supervision will be provided by Big Eagle and Associates. In addition, Big Eagle will provide experienced staff to conduct all tagging through the month of February or until they deem CFS staff to be sufficiently trained to conduct tagging operations independently. Additional technical support will be provided by Northwest Marine Technologies, Inc. Training will entail proper fish handling and tagging procedures, and equipment maintenance and troubleshooting. All staff involved in the tagging procedures will be aware of state permit restrictions. A field crew supervisor/project lead will participate as a member of the sampling team at all times

Tagging Process

Please refer to the *Tagging Quality Assurance/Quality Control* section described earlier.

Data Collection & Reporting

Biological and physical data (primary data) will be recorded for each release group and will be reviewed for accuracy and completeness at the end of each release day. Additional ancillary information regarding compliance or variance in measurement methods or sampling design will also be documented at the end of each release group.

Sample Size and Analysis

Since 1996, rotary screw traps have been fished at Caswell (13.8 Rkm) to determine the characteristics of juvenile Chinook salmon migration in the lower Stanislaus River. The Caswell site was selected as the farthest location downstream in the Stanislaus River with adequate access to install and monitor two traps. Two traps have been fished side-by-side at this site to increase catch rates. The river at this location is about 24 to 30m wide and 1.5 to 4.6m deep, depending on flow.

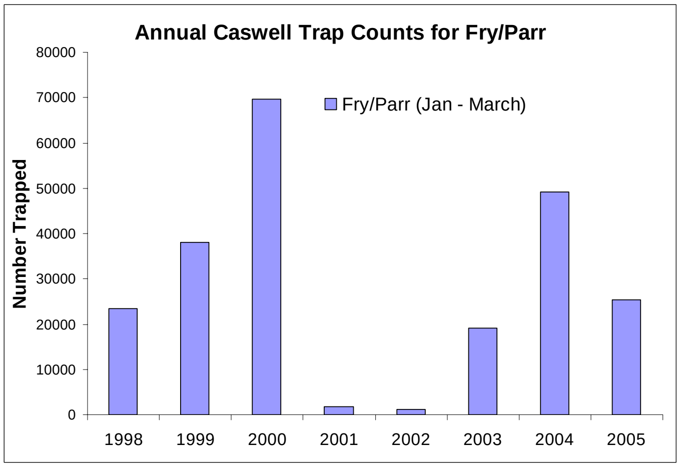
To further increase catch rates in the coming season, we have added a third screw trap downstream of the existing traps. The following anticipated sample sizes are based on catch data for three “wet” years (1998-2000 juveniles migrations) and five “dry” years (2001-2005), and in all cases, conservatively assume that historic catch rates would be increased by about 25% with the addition of a third screw trap.

Based on historic data, we anticipate minimum annual sample sizes for coded-wire tagged juveniles of roughly 25,000 for the fry/parr life stages (i.e., 35-69 mm in length) and 5,000 smolts (> 70 mm) (Table 1). (Note the vast majority of fry/parr will be comprised of fry (35-45 mm) captured during late January through February.) In “wet” years, additional fry/parr are likely to be captured (Table 1), providing an expected sample size of about 55,000 fry/parr. The proportion of total passage represented by captured and tagged juveniles is expected to be 5% or less in wet years, while in dry years, roughly 19% of the fry/parr and 8% of smolts are expected to be captured and tagged (Table 1). Given the maximum historic catches observed and logistical constraints for daily tagging operations, maximum samples sizes are unlikely to exceed 60,000 fry/parr and 10,000 smolts.

Table 1. Anticipated catch of the fry/parr (35-70 mm) and smolt (> 70mm) life stages of juvenile Chinook salmon by rotary screw traps in the lower Stanislaus River. Catch values are the averages across typical “wet” years (1998-2000) and “dry” years (2001-2005). Also shown is the expected proportion (%) of the total passage by life stage caught in the screw the traps.

	Anticipated Catch		% of Total Passage	
Year Type	Fry/Parr	Smolts	Fry/Parr	Smolts
Wet	55,000	5,200	5%	3%
Dry	24,000	5,800	19%	8%

The numbers derived in Table 1 were based on approximate average values of juvenile counts observed at Caswell from 1998-2005. Additionally, these values assumed that an additional screw-trap trap at Caswell will increase counts by 25% of those observed historically. The historic counts at Caswell are shown in Figure 1 for fry/parr (i.e., January to March counts) and smolts (April-May counts).



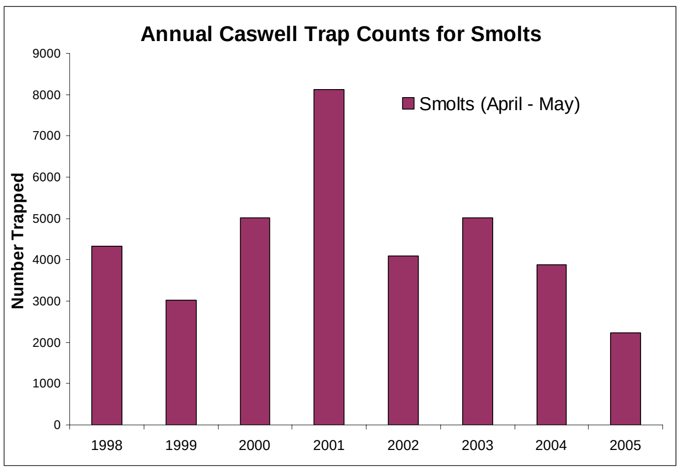


Figure 1. **The historic counts at Caswell for fry/parr (i.e., January to March counts) and smolts (April-May counts).**

Contribution-Rate Estimates

A key objective of the proposed CWT study is to determine the contribution of fry, parr, and smolts to the adult recruitment of Stanislaus River Chinook. Thus, it is important to ask whether or not the anticipated tag-group sizes can provide meaningful insight regarding contribution rates. Specifically, it is important to examine the degree of precision in contribution-rate estimates that would be expected from tag-group sizes of the range discussed above.

The precision of contribution-rate estimates will depend on the number of tags recovered from each group. To estimate the expected precision of estimates, we used the following assumptions:

- There are two basic tag groups: (1) the fry/parr life stages, and (2) the smolt life stage.
- We consider only those tag recoveries expected from spawning surveys, which implies minimum estimates of tag recoveries (additional tag recoveries would be expected from delta and ocean recovery programs).

- We assume a recovery rate of 30% for tagged spawning adults. In recent years, the proportion of spawning carcasses recovered during annual escapement surveys of Stanislaus River Chinook salmon has been estimated to be 30% or higher.
- To estimate the expected juvenile-to-adult spawner survival rate, we assumed that all spawners were age-3 fish and then divided annual estimates of spawner abundance by the estimated juvenile outmigration at Caswell two years earlier.

Thus, a simple calculation for the number of expected tags recovered from adult spawners is:

*Tags recovered = (Tags released) * (juvenile-to-spawner survival rate) * 0.3,*

where 0.3 represents the expected 30% recovery rate of tags during spawning surveys.

Survival Rate Estimates

Estimates of juvenile-to-spawner survival rate depend on the assumed contribution of each juvenile life stage. If only smolts are assumed to contribute to adult recruitment, then estimates of Caswell smolt-to-spawner survival range from 3.2% to 8.1% (avg. = 5.2%) across migration years 1996-2003 (Table 2). Alternatively, assuming all juveniles (fry, parr, and smolts) have similar survival rates, then juvenile-to-spawner survival rate estimates range from less than 1% in wet years (1998-2000) in which there were significant fry out-migrations, to 3% or more in recent dry years (2001-2003).

Table 2. Average annual survival rates for smolts only and for all juveniles combined (Caswell trap).

Migration Year	Smolts only	All juveniles
1996	5.9%	4.7%
1997	6.0%	5.1%
1998	4.3%	0.7%
1999	6.1%	0.5%
2000	3.3%	0.3%
2001	3.2%	3.0%
2002	5.0%	4.4%
2003	8.1%	3.0%
Average	**5.2%**	**2.7%**

In short, we anticipate smolts experience much higher survival rates than fry/parr, but large emigrations of fry, especially during wet years, may provide a significant contribution to adult recruitment despite low survival rates simply because there are so many more fry out-migrating than smolts. Based on the values in Table 2, it seems reasonable to assume smolt-to-spawner survival is, on average, 3% or greater. As observed in Table 3, we would therefore expect 45 tags would be recovered during spawning surveys for a total tag-group size of 5,000 smolts. Now assume fry/parr survival is only one-tenth of smolt survival, i.e., it is only 0.3%. In this case, we would expect roughly 23 fry/parr tags to be recovered during spawning surveys for a total tag-group size of 25,000 fry/parr. Table 3 provides a range of survival rates and tag group sizes that could be expected across the years.

Table 3. Expected number of tag recoveries based on the number tagged, the juvenile-to-spawner survival rate (from Caswell), and an assumed 30% recovery rate of tags during spawning surveys.

	Number Tagged				
Survival Rate	2000	5000	10000	25000	50000
0.1%	1	2	3	8	15
0.3%	2	5	9	**23**	45
0.5%	3	8	15	38	75
1.0%	6	15	30	75	150
3.0%	18	**45**	90	225	450
4.0%	24	60	120	300	600
5.0%	30	75	150	375	750

Tag Recovery Estimates

So, what information is gained from 45 recovered smolt tags (out of 5,000 released) and 23 recovered fry/parr tags (out of 25,000 released)? With respect to contribution rate, we can consider the estimate of differential survival rate between fry/parr and smolts, which is the key data required to estimate relative contribution. In other words, what is the expected precision of the estimated ratio in fry/parr versus smolt survival rate? In our example, this ratio is 0.3% versus 3%, or 0.1. One can simulate the expected distribution of this estimate based on the tag-group sizes and survival rates (e.g., Figure 3). As observed in Figure 3, the 95% interval for the expected distribution (across 5000 hypothetical experiments) of estimated survival ratios ranges from 0.06 to 0.16, where the true value was 0.1. Thus, despite reasonable low sample sizes, we obtain very reliable estimates of the differential survival rate between fry/parr and smolts in this example. The greater the fry/parr survival rate, the better the estimates. Thus, to the extent that we interested in determining if fry contribute at rates of say 5% of those of smolts versus 25% of those of smolts, the proposed CWT study should provide robust data for differentiating among such hypotheses.

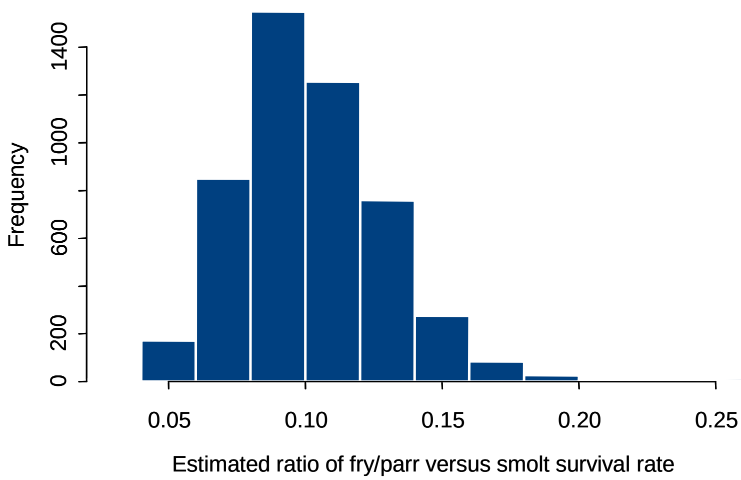


Figure 3. Distribution of estimated ratio of fry/parr versus smolt survival (to adult spawner) based on 5,000 tagged smolts with 3% survival and 25,000 tagged fry/parr with 0.3% survival (recovery of tags limited to spawning surveys with 30% recovery rate). The distribution is based on 5000 bootstrap samples.

Products

Results of the proposed CWT study will provide detailed scientific information regarding the relative contribution of different juvenile life stages to the adult recruitment of Stanislaus River Chinook salmon. The study will also provide information regarding juvenile migration characteristics and the potential effects of conditions in the San Joaquin River, Delta, and early marine habitats on juvenile survival through adulthood. The findings from the study will provide a technical foundation for assessing and refining management recommendations. Sampling efforts will be documented in annual technical reports that provide detailed information regarding the experimental design and results of data collection activities.

Analyses Resulting from Sampling Plan

- Analyze adult recoveries to determine the contribution of fry, parr, and smolts to adult recruitment of Stanislaus River Chinook.
- Examine relationships between annual survival rates by life stage and environmental conditions (e.g., flow, temperature, etc.) during juvenile migration through the San Joaquin River, Delta, and early marine habitats.
- Analyze juvenile recoveries to determine the movement patterns, migration speeds, and growth rates of juveniles, and potentially, the relative and/or absolute survival of juvenile tag groups through the Delta.

Benefits

The rotary screw trap monitoring provides quantitative information on threatened steelhead/rainbow trout and Chinook salmon outmigration timing and survival in the Stanislaus River. The relative contribution to adult fall-run Chinook salmon production by naturally produced fry, parr and smolts is unknown in the Stanislaus River. In order to better manage outmigration flows, it is necessary to determine the proportion of returning and/or harvested adult salmon that outmigrate from the tributaries as fry, parr and smolts relative to streamflow releases and upstream reservoir management. Results from the coded wire tagging effort will provide information needed to develop an instream flow schedule as part of the NMRPO.

Beyond the specific objectives of the study, several additional benefits can also be expected:

- It is likely that at least some CWT wild Stanislaus River Chinook salmon will be recovered by other sampling programs (e.g. USFWS and DFG trawl and seining programs). These recoveries may provide valuable life history insights related to emigration timing, rearing behavior and water project operations.
- The recovery of tagged fish at the SWP and CVP pumping facilities will provide valuable information about how fish size, river conditions, emigration timing and pumping operations may increase or reduce entrainment of wild Stanislaus River Chinook salmon. Currently, little is known about the entrainment vulnerability of wild salmon relative to the patterns that are well understood among hatchery production and experimental releases.
- Ocean fishery recoveries will provide specific information regarding behavior and exposure to harvest for Stanislaus River wild Chinook salmon.

- We do not expect out-of-basin straying to be a substantial problem among wild stocks. However, the recovery (or lack of recovery) of Stanislaus River Chinook salmon at other Central Valley locations (i.e. hatcheries and spawning surveys) could provide valuable data on straying rates for a wild salmon population. This information would be extremely helpful for hatchery management (including ESA compliance) in establishing rates of tolerable straying for Central Valley salmon mitigation hatcheries.

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Addendum 1: Rotary Screw Trapping Operations

Field Monitoring Protocol

Introduction

Figure 1: Photo of a Rotary Screw Trap

Rotary Screw Trapping Protocol

The following protocol gives detailed procedures for the daily operation of a rotary screw trap (Figure 1), including trap operation and maintenance, fish handling and marking, data collection and management, and trap efficiency estimates. Protocols are made to make field activities as safe as possible and to collect data as accurate and unbiased as possible.

Reference List

For additional information, please see Tsumura & Hume 1986, Thedinga *et al.* 1994, Nickelson 1998, Miller & Sadro 2005, Bottom *et al.* 2005, among others.

Study Areas

Stanislaus River

The Caswell study site is located on the Stanislaus River (RM 8) at Caswell State Park. This site was selected in 1995 and juvenile Chinook salmon outmigration data have been collected every year since then. The trapping site is located approximately 100 meters upstream of the State Park boundary. A third trap (second trap site) was installed in 2007 to increase catch numbers for a coded wire tagging program initiated this year. The third trap is located at the upstream property boundary of the park. The upstream Caswell traps are configured in a parallel fashion pined against one another (Figure 2). The third trap is located downstream approximately 100 yards (Figure 3). We access our trapping site by a levee road. A landowner agreement has been established as well as permit with State Parks.

Figure 2: Photo of Caswell traps pinned together in parallel.

Figure 3: Photo of third trap downstream of Caswell traps

The Stanislaus River, like all San Joaquin River tributaries, is control-regulated by dams (i.e., Goodwin, Tulloch, New Melones) and water is diverted for city and agriculture uses. Water can be diverted by canals as well as agricultural pumps. Typically, the average flow on the Stanislaus River is 600 cfs during a dry year; 1,100 cfs during a moderate year; and, 3,000 cfs during a wet year. Other research activities on the Stanislaus River include; but are not limited too; rotary screw trapping at Oakdale Recreation Area, adult migration monitoring using a portable resistance board weir at Jacob Meyers Park, California Department of Fish and Game (CDFG) carcass surveys, temperature modeling, and habitat snorkeling. Gravel augmentation and restoration projects have occurred in the recent past.

General Instructions

Safety first!

Safety should always be your primary concern. Never perform a task if it cannot be performed safely. Stay aware of your surroundings and possible hazards at all times. Make suggestions about improvements to safety procedures, if you have them, to your partner in the field or your Project Manager.

A minimum of two crew members will operate the trap at any time. Each person should have a radio or a cell phone. Life-jackets are to be worn at all times while in a boat, on a trap, or in the river. First Aid kits, emergency road flares, and fire extinguishers will be maintained in all vehicles and boats. Precaution should be taken by personnel to always keep hands, loose clothing, and other items away from the cone, axle and other moving parts during trap operation. Never remove debris from cone or axle while the trap is rotating.

Rotary screw traps and associated rigging are a possible hazard to boaters, swimmers and others using the river. Wires and cables should be marked with bright colored flagging to be easily seen. Signs should be positioned both upstream and downstream of traps to instruct boaters how to avoid the trap. Other protective measure may include flashing lights to improve trap visibility and deflectors to prevent river users and large woody debris from entering trap (Figure 5).

Figure 5: Typical hazard signs for rotary screw traps

Trap Operation and Maintenance

Rotary Screw Trap Description and Diagram

Rotary screw traps consist of a cone, supported on two pontoons, with interior baffles to trap and transfer fish to a livebox (see Figures 1-5). Traps are usually positioned in the stream or river thalweg and angled to catch the maximum amount of flow. The cone is lowered into fishing position with a single hand winch or chainfall. The forward end of the cone should be lowered until the axle is at the water's surface. The trap counter records the number of rotations.

Figure 6: Photo of technicians processing the trap

Trap Operation

Traps are generally checked once a day (Figure 6), but as often as necessary, to maintain a safe holding condition for fish and efficient operation of trap. The frequency of trap checks is dependent on the number of fish collected, level of instream flow, debris loads and objectives of the study. The collection of larger fish may bias catch abundances as they tend to prey on small fish. Predation pressures may require more frequent trap checks. Some investigators have used tree branches, other debris or plexiglass panels to create refuge for small fish inside the livebox. These measures may decrease predation, however other problems may also arise (e.g., increased water velocities, de-scaling, etc.).

Trap Maintenance

The traps are inspected daily for damage and improper wear. The field crew will inspect the livebox seal for any cracks and proper seating around the cone. The cone shaft and bushings will be inspected for cracks and wear (Figure 5). The cone mesh will be inspected for any tears and the access doors will be inspected for proper closure. The winch system will be inspected for proper function, as well as cable and pulley wear. The counter system will be inspected for proper function. The anchor points and cabling system for the traps will be inspected for faults. The traps will be cleaned daily. The cone, pontoons, and livebox will all be scrubbed and free from debris. Maintenance will be performed as inspections warrant such activities.

At the end of the year, traps will be pressure washed and thoroughly inspected for any damage as well as possible improvements.

Figure 5: Photo of technician inspecting the cone of trap

Data Collection and Management

Completing Data Sheets

Data sheets should be clear, legible, and contain all information needed to accurately interpret data (see example, Appendix 1). If there is more than one data sheet for a particular site, make sure they are labeled appropriately (e.g., site name, page 1 of 2, etc.). Please make all information clear enough so someone not familiar with field conditions can interpret data accurately (i.e., use standard abbreviations, no omitted data). There should never be any empty spaces for relevant data on a sheet. If data are not taken, draw a line through the appropriate box and write a short explanation.

Additional comments regarding any variations in procedure, notable field conditions or other pertinent information should also be included. Any river conditions affecting trap operation or change in trap position should be noted.

Please use the following conventions when filling out data sheets:

1. Use your best and clearest handwriting.
2. Organize the data sheet so like species are recorded together. Look at catch before you begin recording data and leave ample space to group data for each species. Use additional sheets to assure clarity of the information.
3. Completely fill out the top block and the appropriate gear section, include the crew names and data recorder's name.

4. Corrections can be made in the field by erasing if the sheet is dry, or putting a line through mistake and clearly writing correct information nearby.
5. Never estimate information. Record measured values only. If a value cannot be measured, put a line in the box and make an explanation in the comments section.
6. Circle all dead fish on data sheet.

Field Quality Check

The first step of data quality assurance/quality check (QA/QC) happens in the field. After completion of sampling, review the data sheet and make sure all information is complete, or collect any missing values. Common errors include blanks, illegible entries, un-entered plus counts (clarity of plus count tallying), incorrect species or station codes, and unclear comments. When you are satisfied data are the correct, sign your initials and date. The field quality check should occur before leaving the site so additional data can be collected if necessary.

This is the first of four checks that must be completed and signed off. The other three are done as or after the data are entered into the computer.

Data Delivery

Data sheets need to be delivered to the Project Manager at the end of each shift. Please do not leave data sheets in vehicles or in clipboards as they may get lost or damaged. (USFWS employees will exchange data sheets with Field Manager on Wednesday trap check.) Extra precautions should always be taken to insure delivery of data to appropriate person.

Data Entry

Data are maintained in Microsoft Access database. Data are entered as soon as possible after collection, ideally on a daily basis. Care should be taken to assure data are entered correctly. The Project Manager will provide all necessary instructions to enter data into the database.

QA/QC Procedure

The goal is to generate accurate, error-free data that can be analyzed with confidence by us and others to address immediate and future management needs. The accuracy of the data are checked by insuring data are collected and recorded without error, and entered error-free into the database.

1. Field Data are Collected Following data collection protocols
2. Data sheets are reviewed for completeness in the field (Field Quality Check)
3. Data are carefully entered into database
4. Data correctness are verified on screen upon comparison with data sheets (Database Verification)
5. Database tables are printed and compared against data sheets as a hard copy verification (Hard Copy Verification)
6. Database tables are locked (write-protected) to prevent accidental changes
7. Data are ready for analysis

Data Entry Quality Check

Data are entered and then verified to insure they have been entered correctly. Data entered in the field will be checked as described above and data sheets will be initialed by field tech. Date and initials of person entering data will be noted on each data sheet.

Database Verification

The verification will be to check for entry errors by comparing data sheets with database entries on screen. As each data sheet is checked, sheets will be signed with initials of person and date verified.

Hard Copy Verification

The final check will be to do a hard copy verification of data. Data tables will be printed from database and compared against data sheets. Corrections, if needed, should be made to database. Data sheet will be signed with initials of person verifying data and date verified. When data quality checks are complete each data sheet should have four sets of initials and dates on it; field check person and date, data entry person and date, database verification person and date, and hard copy verification and date. After the QA/QC of data is complete, database tables will be write-protected and copied to insure unintentional changes are not made.

Fish Handling

General

Fish, especially young salmonids (Figure 6 and 7), are sensitive to changes in temperature, oxygen levels, sunlight and a variety of other factors. Care should be taken to insure cool water temperatures with adequate dissolved oxygen, and all work should take place out of direct sunlight. The proper care of fish is extremely important as some species captured may be (or become) listed under either the federal or state Endangered Species Act. Special care should be taken to insure all fish are handled properly and mortalities stay extremely low. In general, fish should spend as little time as possible away from their home environment.

Figure 6: Newly emerged Stanislaus Chinook "yolk-sac" fry

Fish collected from a rotary screw trap livebox may be tired and/or stressed from the increased water velocities created, and the avoidance of predators. When removing fish from the livebox, be careful not to injure fish between the rim of the dipnet and the wall of the livebox. The livebox corners are typically where fish are injured and killed. Make every effort to chase fish out of livebox corners before netting them.

Figure 7: First Chinook fry of 2007 trapping season

Temperature/Oxygen

Coolers may be used instead of buckets as insulated walls keep water temperatures lower longer. When using buckets check temperature often and shade buckets. When transferring fish between locations (e.g., hauling tank to river, bucket to holding tank, etc.), always check temperature difference between environments. Differences greater than 4°F can cause loss of equilibrium and stress and should be avoided. Make sure fish are not overcrowded (25-50 individuals per bucket; 100-150 individuals per standard-size cooler). Use a DO meter to check the dissolved oxygen levels (7-10 mg/L). Refresh water if DO level falls below 5 mg/L.

If fish exhibit strange behavior, transfer them to another bucket/cooler to replenish oxygen and gently lower water temperatures.

Direct Sunlight

While working with fish, avoid their exposure to direct sunlight. Find or create a shaded place to measure and weigh fish. Cover all buckets and net pens while in use.

Anesthesia

Finquel® MS-222 (Argent Chemical Laboratories) is a safe and effective anesthetic for fish and other ectotherms. The action of MS-222 is readily reversed when fish are transferred to fresh water. The effectiveness is related to a variety of factors including concentration, fish size, water temperature, stock solution age and exposure to sunlight.

Fish are immersed in a bath of MS-222 (10-60 mg/L concentration; we are using 26.4 mg/L) and the following sensory and motor responses of the fish characterize progressively deeper levels of anesthesia:

1. Sedation – decreased reactivity to visual and vibrational stimuli; gill activity reduced
2. Total Loss of Equilibrium – Fish turns over; locomotion increases; fish swims or extends find in response to pressure on caudal fin or peduncle
3. Total Loss of Reflex – No response to pressure on caudal fin or peduncle; opercular rate slow and erratic
4. Medullary Collapse – gill activity ceases

Overexposure (in time or concentration) to MS-222 will lead to death for fish and other ectotherms. Watch for gill activity, if gill activity ceases immediately transfer fish to fresh water. Monitor time while fish are immersed in MS-222 bath. A rough estimate of safe exposure can be made by multiplying the time required to reach sedation by 2 or 3. Know your time for safe exposure and do not exceed.

Precautions for the use of MS-222:

- Avoid inhaling or getting in eyes
- Always conduct preliminary tests of a few fish to determine rates of anesthesia and optimal length of exposure
- Do not overexpose fish
- Do not anesthetize more fish than can be handled during optimal length of exposure
- Do not use water containing chlorine
- Insure adequate oxygen in anesthetic solution
- Discard anesthetic solutions when fouled with mucus or metabolic wastes
- Do not discard MS-222 solutions into water supplies of natural waters
- Store solutions and dry powder in a cool place away from light. MS-222 solutions may change color to yellow or brown when exposed to light.
- Discard stock solutions when they lose effectiveness (90 days)

Mixing Instructions

A stock solution of MS-222 is prepared at the lab and then 10 mL of the stock solution is added to 4 L of water in the field. All MS-222 solutions should be checked with a few fish to determine potency. StressCoat will be used in MS-222 buckets and recovery buckets to reduce stress.

Equipment:

- Scale
- Container for mixing
- Latex gloves
- MS-222 powder
- Water
- Funnel

Procedure:

To prepare a stock solution of MS-222:

1. Weigh 10.4 g MS-222 using scale
2. Add MS-222 to stock container
3. Fill to the 1 L marked line with purified water
4. Check the pH (with pH test strips). If pH is less than 7, add 1/2 tsp. baking soda and check pH again

To prepare MS-222 to anesthetize fish:

1. Add 1 cap full (10 mL) to 4 L of water (fill line in half buckets)
2. Mix well
3. Add a few fish (2-3) and record time to sedation
4. If time to sedation is 4-5 minutes, proceed with fish processing. If time to sedation is > 5 minutes add an additional 5 mL of MS-222 stock solution, use different test fish and record time to sedation. If time to sedation is < 2 minutes, add more water, use different test fish and record time to sedation again.

Selecting Fish to Measure

A random sample of fish will be measured and weighed (following project objectives). Fish should be selected randomly for measurement to prevent biases for or against the slow or larger fish in the container. Juvenile salmon will also be grouped according to size class (fry/parr/smolt). The first 50 salmonids per week in each age class will be measured and weighed. The first 20 of all other fish species will be measured each week (no need to weigh other species of fish). A dip net should be used (versus bare hands) when catching fish to be measured. All fish measurements will be fork length in millimeters. Total length will be taken on fish species without a forked caudal fish (e.g., sculpin) and a notation of using total length will be made on data sheet. Do not place too many fish on the measuring board at a time. Hands, dipnets, and measuring boards should always be wet before coming in contact with fish.

Fish Marking

General

Fish are marked with colored dye using a needless injector (MadaJet™) which places a small, semi-permanent dye mark between fin rays (Figure 8). Marks may last for several weeks, however fish used for trap efficiencies will generally pass the trap after only a few days. Marks are usually placed on the caudal fin for fry-size fish; however, the dorsal and anal fins can also be marked when fish are larger than 45 mm. Several studies have used this type of mark for mark-recapture studies (Bottom *et al.* 2005, Miller & Sadro 2005, etc.).

Figure 8: Typical caudal fin mark in fluorescent pink

Equipment checklist

Clipboard with:
MS-222 stock solution
Data sheets
Thermometer
Syringe
Pencils

MadaJet toolbox with:
Extra seals
Marine grease
Alcohol
Toothbrush
Dye powder

Inoculators
Towels
Dye and syringe
Half-bucket(s)
3-5 Buckets
Dip net
Scoop net
Canopy
Stress coat
Aerator
Nylon rope for net pens

1 Net pen minimum for each mark applied labeled with metal tag
Waders
Wading boots
Ice chests
Card table
Chairs
Large bottle of water
Latex gloves
Spade
Tool box

Marking Procedure

1) Set up your location (Figure 9)
    a) Set up table, chairs and canopy (not shown)
    b) Start a new data sheet – Marking Data Sheet (see Appendix 4). Record date, start time, water temperature and mark to be used.
    c) Fill guns with the appropriate dye using a syringe.
    d) A wet plastic cutting board can be used as a marking surface.
    e) Fill cooler ½ way with water, attach aerator, add Stress Coat and up to 150 fish at a time.
    f) Mix MS-222 in half bucket.
    g) Fill recovery buckets about ½ full and add

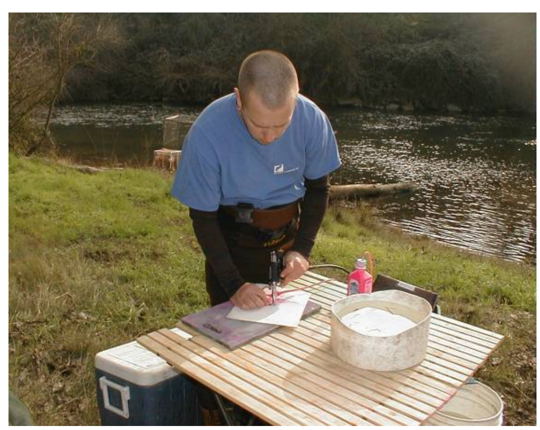


Figure 9: Technician marking Chinook fry with MadaJet

Stress Coat. A cooler can also be used, but fish must be transferred to net pen in buckets. Never try to transfer fish from a cooler into a net pen.

h) Place about 20 fish per marker in the MS-222 after it has been tested.

2) Start marking
    a) Measure fish if necessary, record value on data sheet and place fish on plastic cutting board one at a time.
    b) Apply the mark by cocking the gun and lightly placing the tip onto the appropriate fin then pressing the button (Figure 5). Be careful not to mark too close to the body or too close to the margin of the fin. See Figure 6 for proper mark placement.
    c) Count marked fish, place in recovery bucket and record tally on data sheet. Always check to be sure your fish are recovering normally and have visible marks.
    d) If the guns jam, remove fish from MS-222 before trying to fix jam. Guns can usually be fixed by running clean water through them. NEVER put river water in the guns – they will clog. If this does not solve the problem after a few attempts, try using a different tip. Disassembly of guns should be avoided in the field.
    e) When 75 fish have accumulated in recovery bucket, transfer fish to net pen.
    f) After 150 fish have been marked mix new (and test) MS-222 in ½ bucket, as it loses its effectiveness.
    g) After all fish have been marked, record your end time and the total number of fish marked on your data sheet. Mortalities should be subtracted from total count. *(Note: save all mortalities for use in determining coded wire tag placement.)*
3) Clean up
    a) Carefully remove rocks from net pen, seal Velcro and reinforce with zip ties. Review date, mark applied and number marked on the metal tag for correctness.
    b) Attach net pen to secure location (e.g., back of trap). Tie net pens so the water surface is about 1-2 inches below the underside of the plastic rim.
    c) Clean and load up all supplies. MadaJets should be cleaned thoroughly with clean water. NEVER put a gun back into its case with dye in it. Be sure that nothing is left behind.
    d) Field check data sheet for completeness and correctness.
    e) Return all supplies to storage.
    f) Make sure equipment is ready to be used again.

Measuring Physical Parameters

Water Temperature

Water temperature has an effect on salmon survival and is recorded during each trap check. Take temperature in water at least 0.5 meter deep and wait until a stable reading is obtained. Record the reading in the appropriate space on data sheet. The scale used is generally °C. The temperature should be taken every time the trap is set or processed.

Turbidity

Each day a water sample is collected for turbidity measurement. Collect water in a clean glass or plastic vial. Label the vial on the lid and the side with date and sampling location with a Sharpie. Use the LaMotte Turbidimeter to determine turbidity level for each sample at the end of the day and record value on corresponding data sheet. Each sample must also be logged in the equipment log sheet with the date, client and number of samples you tested. Refer to manual for more information about the use, calibration and maintenance of the turbidimeter.

Water Velocity

Water velocity will be taken in front of each screw trap. The average velocity of each trap should be taken halfway between the right pontoon and shaft about 0.5 m below the surface and recorded on the corresponding data sheet. Make sure the flow meter is using m/s and be sure to re-zero the readings for average and maximum velocity before taking a reading. Refer to Appendix 3 for more information about the use, calibration and maintenance of the flow meter.

Status Readings

Determining Revolutions per Minute (RPM)

Revolutions per minute to the nearest tenth will be recorded at the start (“before revs”) and end (“after revs”) of the sample period.

Determine RPM as follows:

1. As the screw trap cone spins, find a marker on cone (i.e., bolt) to determine how many times the cone makes a complete revolution in one minute.
2. Use a stopwatch and count the number of times the bolt (or other marker) passes the crossbar in one minute.

Determining Condition Code

Condition code describes the trap activity during the sampling period and records an element of variability in trap performance. Condition code definitions are as follows:

- **1** Good (normal)
  - Indicates the trap is fishing well
- **2** Fair
  - Describes situations resulting in partial blockage, but water and fish are still delivered to the livebox
- **3** Poor
  - Describes conditions that prevent collecting fish in the trap or may allow fish to escape from the livebox while the trap is fishing
  - The condition of the trap is poor when the RPM is < 1.0
- **4** No sample taken
  - Described any situation when fish were not able to be collected from trap

Determining Gear Status

Gear status tracks the check frequency, when traps are raised and lowered and when the trap has been serviced. Gear status code definitions are as follows:

0 = Cone is lowered and fishing begins (no sample taken)
1 = First trap check of the day
2 = Second trap check of the day
3 = Trap has been serviced and cone raised

Revolutions Counter

A counter is located near the front of the cone where revolutions per day are recorded. Record the number in the Total Revs blank on the data sheet. If the revolutions counter is not functioning or the trapping cone is not jammed by debris, record the counter reading and explain the circumstances in the comments section.

Daily Procedure

Trap Safety

Be cautious when moving around on the trap. A number of hazards exist on and around the trap (e.g., winch, cleats, cables, frayed cable, etc.). Stay aware of these hazards and always use great caution when moving and working on traps. NEVER move across the number one crossbeam (in front of the trapping cone) when the trap is fishing. A catwalk may be installed on the front of the trap. Always use extreme caution on the catwalk. Pay attention to other crewmember locations and activities on the trap, boat traffic and boat wakes, and during high flow conditions, watch for large debris that may collide with the trap and have an unexpected effect.

All crew members need to be at attention when boat is approaching and docking at trap. NEVER place any part of your body between boat and trap during approach or while moored. The boat operator should drive slowly when approaching the trap and use fenders if available. Crewmembers should be able to step, not jump, from the boat to the pontoon. Boat motor can be shut down once everyone is safely on the trap and boat is secure. Make sure fenders are adjusted properly to prevent contact damage to boat or trap. Be very careful when stepping on or off the trap, or walking on the trap. Pontoons and livebox lid may be slippery, due to ice/frost in winter and algal growth in spring/summer.

Check winch cable and mooring cables for fraying. Use caution when handling frayed cables to avoid injury to hands.

When raising or lowering the cone or livebox door, everyone should be aware and in a safe position. The person changing cone position or opening livebox door should communicate their actions to others and make sure other field technicians have heard them and are aware. When the trapping cone is being lowered, keep hands and feet away from crossbeam when it contacts the pontoon. Always secure the livebox door in the open position.

Equipment Checklist

<u>Clipboard containing:</u>	<u>Toolbox containing:</u>	<u>Other:</u>
Data sheets	First aid kit	Paddles
MS-222 vial	Flashlight	Life-jackets
Laminated code key	Rescue rope	Park/gate keys
Pencils/Sharpies	Pocketknife	Ice chest
Fish ID book	Counter Bolts/Nuts	Digital Camera
Thermometer	Metal tags	½ bucket for MS-222
Knife	Crescent wrenches (2)	Chainsaw (when flows are high)
Water sample vials (2)	Screw drivers	Dip net (1)
Syringe	Nylon rope	Waders
Scale sample envelopes	Zip ties	Wading boots
Stop watch	Dykes	Flow meter
		John boat
		Measuring board
		Scoop nets (2)
		Scrub brushes (2)

Morning Check Procedure

1) Arrival at the site
    a) Record location, station, recorder, crew, time and date on data sheet.
    b) Observe trap function and make sure it is operating properly.
    c) Record Gear Status and Condition Code on data sheet.
    d) Measure the water temperature and velocity; record values on data sheet.
    e) Measure the revolutions per minute and record on data sheet as before revs.
    f) Board trap. Make sure the trap continues to operate after boarding. Record Total Revs from the counter. Clear counter.
    g) If there is debris in the cone, stop the trap before removing. NEVER reach into a moving cone!

2) Cleaning the livebox(es)

(Raising the trapping cone creates a gap through which fish can escape, so it is best to clean the livebox while trap is operating. Make sure to keep hands and nets away from moving parts of trap.)

    a) Fill bucket about ½ full of water.
    b) Scoop no more than ½ netfull of debris at a time. Gently empty contents onto the trap deck.
    c) Carefully sort through the debris using a stick (or other probe). DO NOT use your hands; hypodermic needles are encountered. Natural debris can be returned to the river; man-made trash must be collected and properly disposed.
    d) Carefully find and remove all fish (some will be very small). Place them into your bucket. Make sure fish are not overcrowded in buckets (< 25 small fish per bucket).
    e) Make sure water temperature in bucket remains low (10-20°C; 50-68°F). Add cool water, frozen water bottles, or exchange the water, if it becomes too warm.
    f) If there are too many fish to hold in buckets or coolers while processing, leave fish in the livebox and process fish in small batches.

3) Processing the Trap Catch
    a) Prepare MS-222 in the half-bucket. Fill half-bucket to fill line (4 L) and add 10 mL of MS-222 stock solution. Test your solution strength with a few fish. Fish should be sedated after 2-5 minutes in solution. The solution may need slight adjustments depending on the size of fish, water temperature, and age of MS-222 stock solution. If solution is too weak and fish are not sedated after 5 minutes, put test fish in fresh water, add another 5 mL and test again with fresh test fish. If solution is too strong (fish become sedated in < 1 minute), add more fresh water.
    b) Fill at least 2 buckets (or coolers) about ¾ full of water to be used for recovery. Use one bucket for juvenile Chinook and the other for all other species.
    c) Fish must be anesthetized to weigh and measure. The first 50 Chinook fry/parr (age-0) need to be weighed and measured, and the first 20 of all other species (larval lamprey need only be counted). All Chinook smolts will be measured and weighed. Also record Smolt Index, a measure of life stage (see Appendix 2).
    d) Add fish to be measured to MS-222 solution after it has been tested. Do not put more than about 25 fish in MS-222 at any one time. Measure, weigh and

determine Smolt Index for each fish, put fish in recovery bucket, and record values on data sheet.

e) All juvenile Chinook need to be checked for marks. Check for marks as fish are being measured, or using a plexiglass viewer (if available) for those not measured.

f) Scale samples will be taken every week from 25 juvenile Chinook smolts. Scale samples are collected using a clean pocketknife to gently scrape a few scales from the fish behind the dorsal fin above the lateral line. The scales are then wiped into a paper-lined coin envelope labeled with the date, station, species, Smolt Index, fork length and weight. (If smolts have coded wire tags, sequential code is included on envelope.)

g) Count the number of individuals of each species that exceeds the number measured, and record value in the "plus count" column.

h) After fish have recovered (i.e., swimming and reacting normally), the bucket containing other species can be slowly emptied off the back of the trap. If the number of juvenile Chinook is less than 25 fish are released, however when catches are > 25, fish are saved for efficiency estimates (see below). Fish will be saved in a net pen or live car (Figure 10) which is labeled with date, number of fish and mark (if no mark, label natural) on a metal tag which you attach to net pen in a visible spot. Clean the net pens each time you add or remove fish.

Figure 10: Holding pen or live car (both ends net)

4) Marking fish for efficiency estimates
   a) Mark fish for efficiency estimates (see Fish Marking section) and then transfer marked fish to a clean net pen. Record the mark on the metal tag.
   b) Clean all marking equipment and return to its proper location.

5) Cleaning the trap and recording final data
   a) Use scrub brushes to clean the cone, pontoons, livebox and deck after processing fish. If any debris remains in the cone, raise it and remove. Never climb inside the cone, moving or not. Never try and clean debris out of a moving cone. If the counter was reset prior to raising the cone, reset it again after the cone is lowered.
   b) After cleaning, take the revolutions per minute and record as "after revs" on data sheet.

Evening Check Procedure

1) Arrival at site
   a) Record location, station, recorder, crew, time and date on data sheet.
   b) Observe trap function and make sure it is operating properly.
   c) Record Gear Status and Condition Code on data sheet.

d) Measure the water temperature and velocity; record values on data sheet.
e) Measure the revolutions per minute and record on data sheet as before revs.
f) Board trap. Make sure the trap continues to operate after boarding. Record Total Revs from the counter. Clear counter.
g) If there is debris in the cone, stop the trap before removing. NEVER reach into a moving cone!

2) Cleaning the livebox(es)

(Raising the trapping cone creates a gap through which fish can escape, so it is best to clean the livebox while trap is operating. Make sure to keep hands and nets away from moving parts of trap.)

a) Fill bucket about ½ full of water.
b) Scoop no more than ½ netfull of debris at a time. Gently empty contents onto the trap deck.
c) Carefully sort through the debris using a stick (or other probe). DO NOT use your hands; hypodermic needles are encountered. Natural debris can be returned to the river; man-made trash must be collected and properly disposed.
d) Carefully find and remove all fish (some will be very small). Place them into your bucket. Make sure fish are not overcrowded in buckets (< 25 small fish per bucket).
e) Make sure water temperature in bucket remains low (10-20°C; 50-68°F). Add cool water, frozen water bottles, or exchange the water, if it becomes too warm.
f) If there are too many fish to hold in buckets or coolers while processing, leave fish in the livebox and process fish in small batches.

3) Processing Trap Catch

a) Prepare MS-222 in the half-bucket. Fill half-bucket to fill line (4 L) and add 10 mL of MS-222 stock solution. Test your solution strength with a few fish. Fish should be sedated after 2-5 minutes in solution. The solution may need slight adjustments depending on the size of fish, water temperature, and age of MS-222 stock solution. If solution is too weak and fish are not sedated after 5 minutes, put test fish in fresh water, add another 5 mL and test again with fresh test fish. If solution is too strong (fish become sedated in < 1 minute), add more fresh water.
b) Fill at least 2 buckets (or coolers) about ¾ full of water to be used for recovery. Use one bucket for juvenile Chinook and the other for all other species.
c) Fish must be anesthetized to weigh and measure. The first 50 Chinook fry/parr (age-0) need to be weighed and measured, and the first 20 of all other species (larval lamprey need only be counted). All Chinook smolts will be measured and weighed. Also record Smolt Index, a measure of life stage (see Appendix 2).
d) Add fish to be measured to MS-222 solution after it has been tested. Do not put more than about 25 fish in MS-222 at any one time. Measure, weigh and determine Smolt Index for each fish, put fish in recovery bucket, and record values on data sheet.
e) All juvenile Chinook need to be checked for marks. Check for marks as fish are being measured, or using a plexiglass viewer (if available) for those not measured.

f) Count the number of individuals of each species that exceeds the number measured, and record value in the “plus count” column.
g) After fish have recovered (i.e., swimming and reacting normally), the bucket containing other species can be slowly emptied off the back of the trap. If the number of juvenile Chinook is less than 25 fish are released, however when catches are > 25, fish are saved for efficiency estimates (see below). Fish will be saved in a separate net pen from the morning catch which is labeled with date, number of fish on a metal tag which you attach to net pen in a visible spot. Fish collected at night will be marked the next day. Clean the net pens each time you add or remove fish.

Trap Efficiencies

General

Trap efficiency is affected by river stage, trap placement, life stage and species of fish. Population abundance of juvenile migrants can be estimated using the trap-efficiency method of releasing marked fish upstream of each trap (Thedinga et al. 1994). Our objective was to mark and release fish daily (if suitable numbers of fish were available), and all recaptures per week are pooled so estimated number of migrants were stratified by week. When catch numbers are low efficiency estimates are limited by the available number of fish for marking. We determined a minimum release size of 25 marked fish and a maximum of 500 fish. Each size-class of juvenile Chinook (fry/parr/smolt) are treated separately as the efficiency of the trap is known to differ by species and size. By measuring trap efficiency as often as possible, we are minimizing experimental bias in estimates which can cause over- or underestimations of population abundance. We released marked fish on either side of the river (based on a coin toss) to aid in uniform mixing of unmarked and marked fish. Thedinga et al. (1994) determined marked fish released at standard release sites were uniformly mixed with unmarked population when river side was alternated. Fish are released at night to minimize predation.

After evening check, marked fish will be released for trap efficiency estimates. Night crew will monitor trap after release for several hours to insure collection and record of marked fish (avoiding the possibility predation pressures within trap will affect recapture number).

Procedure

1) Check marked fish to determine mark retention and mortality
   a) Start a new data sheet – Trap Efficiency Data Sheet (see Appendix 3). Record date, location, and weather code.
   b) Fill buckets ½ full of water and retrieve fish marked by morning crew.
   c) Check each fish for a mark using a plexiglass viewer. Count the number of fish with visible marks and the number of mortalities, and record on data sheet. Fish without visible marks can be released below trap as they will not be used in efficiency test.
2) Release marked fish upstream of trap

a) Marked fish will be released upstream of trap and then crew will monitor the trap to determine number of marks recaptured.
b) Fish will be released after dark, and after the trap has been processed. A standard release site will be used, but fish will be released on either side of the river, according to a coin toss. The side of the river where fish are released should be recorded on data sheet.
c) Fish will be released into the river in small batches. Avoid the use of lanterns or other lights as fish are released (if possible to do so safely). Avoid running boat between release point and the trap after release has begun. If a boat is used to release fish and must travel downstream after release, remain 15 minutes at the release point after release and float or row downstream.
d) At release, make sure the following are known and recorded: release time, number of fish marked, number of mark mortalities, number of fish released and mark color (or type).

3) Check livebox for recapture of marked fish
   a) After 1 hour, clean livebox according to the evening check procedure. Record and process all fish collected by usual procedure and record on Trap Efficiency data sheet. Carefully check all juvenile Chinook for marks. Record length and weight of marked fish collected and record on data sheet.
   b) (Optional) Wait another hour and repeat trap check. Record and process all fish collected by usual procedure and record on Trap Efficiency data sheet. Carefully check all juvenile Chinook for marks. Record length and weight of marked fish collected and record on data sheet.
   c) Any remaining marked fish will be collected during the morning trap check.
   d) Make sure data sheets are complete and delivered to the Project Manager as soon as possible.
   e) Make sure site is clean and no equipment is left behind.

Appendix 1 – Example Data Sheet

Location: CASWELL /L Station: ST004L Recorder: JD Crew: MJ, JD Pg 1 of 1

Time: 9:00 Date: 2/6/07 Gear Status: — Condition Code: 1 Water Temp: 49.3 °F Weather Code: CLR Stream Gauge: 1.00

Water Velocity: 1.89 ft/s Turbidity: 1.14 NTU Debris Level: C/T Total Revs: 1888 Before Revs: 114 (sec) After Revs: 111 (sec)

Comments: B.O = 11.45 Reset trap @ 10:30

Species Code (RBT or CHNF)	1			2			3			4			5			6			7			8			9			10			Plus Count
	FL	TL	WT	FL	TL	WT	FL	TL	WT	FL	TL	WT	FL	TL	WT	FL	TL	WT	FL	TL	WT	FL	TL	WT	FL	TL	WT	FL	TL	WT	

Other Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Plus Count
WHC	57																				
MQK	27	32																			

Entered By:_______ On Date:_________ QC_1 By:_______ On Date:_________ QC_2 By:_______ On Date:_________

Appendix 2 – Smolt Index Protocol

The Smolt Index is to determine the life stage of salmonids, including Chinook, rainbow trout and steelhead. Smolt Index should be recorded for each fish measured and weighed.

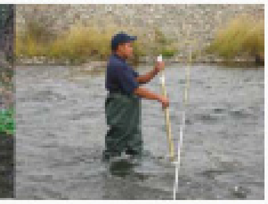
1. Measure the specimen – to the nearest 0.5 mm for those smaller than 100 mm and to the nearest 1 mm for larger fish.
2. Weigh the fish and record weight to the nearest 0.1 g
3. Determine the life stage according to the following table:

Smolt Index	**Life Stage**	**Criteria**
1	Yolk-sac Fry	- Newly emerged with visible yolk sac
2	Fry	- Recently emerged with sac absorbed (button up fry) - Pigmentation undeveloped
3	Parr	- Darkly pigmented with distinct parr marks - No silvery coloration - Scales firmly set
4	Silvery Parr	- Parr marks visible but faded - Intermediate degree of silvering
5	Smolt	- Parr marks highly faded or absent - Bright silver or nearly white coloration - Scales easily shed (deciduous) - Black trailing edge on caudal fin - More slender body
6	Adult	- > 300 mm FL - If < 300 mm FL, must be extruding eggs or milt

Appendix 3 – Flow Meter Instructions

Quick Reference

Flow Probe FP101 & 201



Water Velocity Measurement
Maximum & Average Velocities Displayed Digitally In 8 Languages.

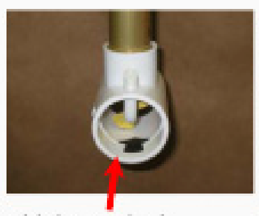
• **Factory-calibrated & ready for immediate use:**

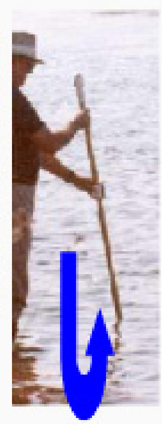
• **Blow on the propeller** for 5 – 10 seconds to ensure it turns freely.

• The Flow Probe computer display uses **2 buttons for normal operation:**

• **Reset the computer display** by holding the top button down for 2 seconds. Instantaneous velocity is always displayed. Scroll through display modes with the bottom button to select Average or Maximum speed. Velocity is displayed in ft/sec or m/sec (Instantaneous velocity to nearest 0.5, Max to nearest 0.1, Avg to nearest 0.01).

• **Orient the propeller** directly into the flow using the arrow indicator aimed downstream

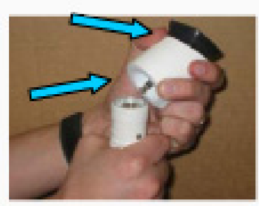




• With the propeller at your measuring point, **hold the probe in place for several seconds**, and then remove the probe. The Average Velocity reading will hold once the propeller stops turning. **Conversely, move the probe in a smooth vertical motion** (as if painting with a brush) to attain the Average Velocity of a water column.

Some things to be aware of:

- Be sure the white end piece is securely snapped into place.
- While the top of the computer is water resistant, operation can be affected if water gets into the connectors that hold it to the probe. If the probe head gets wet, remove the white housing from the probe, separate the computer from the housing and take out the battery. Allow to dry completely.



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Addendum 2: CWT Release Report

CWT RELEASE REPORT

Coded-Wire-Tag Code_____- ______ - ______ - _______ - _______ has been assigned to you. This form must be completed, and returned within 10 days after the tag group has been completely released to: Robert Kano, California Department of Fish & Game, **Habitat Conservation Division, NAFWS, 830 S Street, Sacramento, CA 95814, Phone 916-327-8758. FAX 916-327-8854.**

1. Assigned to______________________________________
   Person Project/Facility

2. Species Chinook Salmon______ Race___________

   *Egg Lot No._________________ Brood Year_____

3. Release Location_______________________________

4. Dates that Group was released:

   First___/___/___ Last ___/___/___
   mm dd yy mm dd yy

5. Rearing type: Hatchery_____ Wild____ Mixed

6. Purpose of Release Group: _____________________

7. Total Number of Fish Tagged ____________

8. Number of Fish with Shed Tags and Poor Fin-clip: ____________
9. Number of Mortalities Prior to Release: ___

10. Number of Fish Released Correctly-tagged: __________
11. Number of Unmarked Fish Released: _________________________

12. Method of Determining Number of Unmarked Fish Released:
    Book Estimate______ Actual Count______ Weight Sample

13. Days Tagged Fish Held for Quality Control. _____

14. Number/lb. of Fish at Release:____

*15. Average Fork Length (mm) at Release: ________

16. Expected Survival:
    Normal_____ Destroyed______ Problem at Release

17. Rearing Location:__________________________
18. Stock of Release Group:______________________
*19. Comments:__________________

*Optional information, all other fields must be completed.

Addendum 3: Response to Comments Regarding the Study Plan

Memorandum

To: J.D. Wikert, Brian Deason, Mike Finnegan
CC: Stanislaus Fish Group
From: Cramer Fish Sciences
Date: 1/26/07
RE: Update on Stanislaus Coded Wire Tag Study

Greetings,
The tagging season is upon us and we are happy to report the CWT study will be underway shortly. A third screw trap has been installed in the lower river and is fishing successfully, the tagging trailer has arrived at the site, the tagging crew (including experienced staff provided by Big Eagle & Associates) are receiving training at the Feather River Fish Hatchery. The completed tagging trailer will be moved to the Caswell site on February 2nd, and we expect tagging will begin on February 6th, if not earlier. Many of you have taken the time to respond to our requests for review and comment of the study design, and we appreciate your input. In response to many of those comments, we have made changes to the attached study plan. During this first tagging season, we will continue to refine our methods as we gain insight into ways we can improve the study design. The following provides an overview of the range of comments we received and our response to each.

We look forward to a successful and informative tagging season. If you are interested in a field visit to view the tagging operations, please contact Ayesha Gray or Ryan Cuthbert at 209-847-7786.

Sincere Regards,

Brad Cavallo, Ayesha Gray, Brian Pyper, Kathryn Arendt
Cramer Fish Sciences Team

Comment: Fish tagging objectives are too low to provide reasonable number of recoveries.

***Response**:* We assert the anticipated numbers of tagged juveniles at Caswell and subsequent recovery of tags are indeed sufficient to provide clear and insightful information regarding relative survival rates of different juvenile life history stages. Our anticipated tag-recovery rates are based on wild juvenile-to-spawner return rates estimated across out-migration years 1996-2004. The source data are juvenile population estimates from out-migrant trapping at Caswell, and in-river adult escapement estimates from carcass surveys and weir counts. These data provide the best available information regarding juvenile-to-adult spawner return rates for wild fall-run Chinook salmon in the Stanislaus River. In the following, we describe in detail the analyses that led to our assertion, including the development of our anticipated release groups and recovery estimates, a power analysis and precision estimate, and an explanation of why other CWT releases do not provide adequate information for our study,

Anticipated Release Groups and Tag Recoveries

In the study proposal, we presented the range of observed Caswell trap counts for the fry/parr and smolt groups for 1998 to 2005 (please refer to the original proposal). (Note: the 1996 and 1997 year were omitted due to anomalously low of parental spawner abundances of 619 and 168, respectively, and would therefore not be expected to produce juvenile abundances typical of subsequent years or the current study year). Across years, smolt counts ranged from roughly 2,200 to 8,100 (average = 4,400). With the exception of the low-flow years 2001 and 2002, the fry/parr counts ranged from 19 to 70 thousand (average = 37 thousand). We then assumed the addition of a third trap would increase catch rates by 25%, which was the general basis for our established tagging targets of 5 thousand smolts and 25 thousand fry/parr. It should be noted that if catch rates were increased by 25%, then the smolt target of 5 thousand would have been met in 5 of 8 years, with only two years being appreciably lower (2,800 in year 2005 and 3,800 in 1999). (Also note the third trap has been installed, and preliminary numbers indicate this trap may well exceed our expectations.)

Although these targets appear low, in particular the smolt numbers, further analyses suggested survival rates of juveniles from Caswell to adult spawning were historically high. We elaborate on these estimates here. Because our estimates are based on out-migrant trapping at Caswell, conducted since 1996, it is important to comment on the reliability of these data.

From 1996-2005, over 150 mark-recapture experiments were conducted to evaluate the trap efficiencies at Caswell across various conditions (multiple replicates per year, covering a wide and representative range of flow, turbidity, temperature, and life-stage conditions). These data were analyzed and trap-efficiency models were developed for estimating total passage numbers based on observed trap counts. In brief, we found trap-efficiency models based on flow and fish size provided good fits to the mark-recapture data. Detailed variance estimators were developed to estimate the precision of passage estimates, accounting for inter-annual variability, variances and covariances of predicted trap efficiencies, sampling variation in counts, and over-dispersion in model predictions and counts. In sum, we determined annual passage estimates were quite precise at the Caswell trap location, with coefficients of variation ranging from 12% to 17% across years. In other words, approximate 95% confidence intervals for annual passage estimates were roughly plus or minus 34% of the estimates (e.g., 100 +/- 34). We therefore have considerable confidence the Caswell data provide a reasonable indication of approximate juvenile passage in the lower Stanislaus River. Passage estimates and average trap efficiencies are presented in Table 1.

Table 1. Annual juvenile passage estimates and average catch rates (trap efficiencies) at Caswell, and estimated juvenile-to-spawner return rates. See text for details.

	Passage Estimates (thousands)			Catch Rates				Juvenile-spawner return rate	
Year	Fry/parr (Jan-Mar)	Smolts (Apr-May)	Total	Fry/parr (Jan-Mar)	Smolts (Apr-May)	Spawners (2-yr lag)	Adjusted	Smolts	All juveniles
1996	13.3	52.5	66	6.0%	3.2%	3087	2470	4.7%	3.7%
1997	NA	72.4	72	NA	2.6%	4349	3479	4.8%	NA
1998	977.2	199.8	1,177	2.4%	2.2%	8498	6798	3.4%	0.6%
1999	1,407.3	115.2	1,522	2.7%	2.6%	7033	5626	4.9%	0.4%
2000	1,928.8	205.7	2,135	3.6%	2.4%	7787	6230	3.0%	0.3%
2001	13.5	150.3	164	12.8%	5.4%	4848	3878	2.6%	2.4%
2002	12.8	88.3	101	9.1%	4.6%	4408	3526	4.0%	3.5%
2003	69.5	61.5	131	15.6%	8.2%	4121	3297	5.4%	2.5%
2004	354.1	57.7	412	13.9%	6.7%	3051	2441	4.2%	0.6%
2005	211.5	44.2	256	12.0%	5.1%				

At this point, a simple exercise can be used to consider expected tag recovery numbers, regardless of the absolute releases sizes for tagged juveniles. Trap-efficiency estimates at Caswell suggest, at a minimum, 2% to 5% of migrating juveniles were caught in the traps across years (Table 1). We intend to tag most of the trapped fish. Thus, we anticipate at least 2% to 5% of the juvenile population will be tagged, and hence, 2% to 5% of the adult returns will contain tags (assuming representative sampling and minor tagging/handling effects on survival). This further suggests that per 1,000 wild spawners, there ought to be 20 to 50 tagged individuals (i.e., 2% to 5%). Given spawner estimates have been equal to or greater than 3,000 in each of the last 10 years, and assuming a 30% recovery rate, we would expect that on average at least 18 to 45 tags would have been recovered annually during the last 10 years (i.e., 3000*2%*30% = 18 and 3000*5%*30% = 45). Therefore, the comment suggesting that we should expect to recover at most 5 or 8 tags (across ocean and spawning recoveries combined) seems highly pessimistic.

Alternatively, we used the passage estimates to compute rough estimates of juvenile-to-spawner return rates (Table 1) and expected tag recoveries. We have refined these estimates in comparison to the study plan. Because age data for adult returns is limited, we first assumed all spawners return as age-3 fish (the dominant age class). For example, spawners returning in 1998 were assumed to be the recruits of juveniles out-migrating in 1996. (Spawner abundances for 1998-2002 are official CDFG estimates from GrandTab.xls, while spawner estimates for 2003-2006 are total weir counts.) To account for potential hatchery stays, we then reduced the spawner estimates by 20% (see "Adjusted" numbers in Table 1).

Using the "adjusted" spawner estimates, we computed juvenile-to-spawner return rates using only smolt passage estimates (i.e., assuming only smolts contribute to adult production) and using total juvenile passage at Caswell (Table 1). For smolts only, estimates ranged from 2.6% to 5.4% (average = 4.1%). Note, these annual estimates are very consistent, further suggesting the smolt passage estimates at Caswell are reliable. For total juvenile passage, spawner return rates ranged from 0.3% to 3.7% (average = 1.7%) (Table 1).

A priori, we expect survival rates of fry and parr are considerably lower than those of smolts. We used the following conservative assumptions: 3% smolt-to-spawner return rates and 0.3% return rates for fry/parr. Given tagging targets of 5,000 smolts and 25,000 fry/parr, and a 30% recovery rate during spawning surveys, we estimated about 45 smolt tags and 23 fry/parr tags would be recovered on average each year. Here, we provide tag-recovery estimates under more conservative assumptions, whereby only 4000 smolts and 20,000 fry/parr are tagged (Table 2). Two values for smolt survival are shown (1% and 3%), and three values for fry/parr survival corresponding to assumptions that fry/parr survival is only 0.05, 0.10, or 0.25 (Table 2). In the worst-case scenario, whereby smolt survival is 1% and fry/parr survival is just 0.05%, we still expect to recover on average 12 smolts tags and 3 fry/parr tags each year. As discussed below, such low recoveries can still provide meaningful results.

Table 2. Expected number of tags recovered during spawner surveys for two scenarios: (1) Caswell smolt-to-spawner survival = 0.01 (1%) and (2) Caswell smolt-to-spawner survival = 0.03 (3%). In both scenarios, it is assumed that 4000 wild smolts and 20,000 wild fry/parr are tagged at Caswell, and the recovery rate (sampling fraction) during the spawner survey is 30%.

				Expected Recoveries	
Scenario	**Smolt survival**	**Fry/Parr Survival**	**Fry/Parr vs. Smolt Survival Ratio**	**Smolt Tags**	**Fry/Parr Tags**
1	1.00%	0.05%	0.05	12	3
1	1.00%	0.10%	0.10	12	6
1	1.00%	0.25%	0.25	12	15
2	3.00%	0.15%	0.05	36	9
2	3.00%	0.30%	0.10	36	18
2	3.00%	0.75%	0.25	36	45

Summary

In summary, analyses based on 10 years of Caswell trap data strongly suggest we can anticipate a substantial number of tag recoveries under the current proposed study design. Considerations of the expected proportions of juveniles tagged, as well as juvenile-to-spawner return rates, both suggest considerable tag recoveries even under highly pessimistic assumptions. In order for our estimates to be grossly in error, the Caswell trap data would have to be seriously biased (e.g., passage estimates underestimated by a factor of 4 or more). Such biases seem highly unlikely given the general consistency between Oakdale and Caswell passage estimates and the implied survival rates of migrating smolts passing between the two trap sites. In addition, there is considerable evidence wild smolt survival rates approach those computed here. For example, we estimated the average smolt-to-spawner survival rate for wild smolt passage at Mossdale to be 2.3% across migration years 1996-2001 (estimates based on annual Mossdale trawl estimates of total passage of San Joaquin fall-run Chinook versus cohort reconstructed spawner abundances corresponding to each migration year).

Power Analyses and Expected Precision of Estimates

To examine the potential information obtained from the proposed study, we conducted the following analyses. The key estimates of interest are the relative survival rates of fry, parr, and smolts in their contribution to adult production. Here, we examine the statistical power of hypothesis tests and the precision of estimates likely to be obtained under alternative assumptions and different durations of the experiment.

As discussed below, multiple CWT batch codes will be used so juveniles captured at Caswell will receive different codes over the migration period (e.g., on a weekly or bi-weekly basis). However, for the purpose of these analyses, we will assume data are pooled across batch codes to provide reasonable sample sizes for comparing two distinct groups: (1) the fry/parr life stages, and (2) the smolt life stage.

For simplicity, we focus here on the estimated ratio of fry/parr "survival" (i.e., spawner return or contribution rate) versus smolt survival. A priori, fry/parr survival is excepted to be considerably lower than smolt survival, therefore we consider the following null and alternative hypotheses:

> H0: fry/parr and smolt survival are equal (not different).
> HA: fry/parr survival is less than smolt survival.

To test this hypothesis, we can use a paired-sample t-test to examine differences in survival estimates across years. Consider the following annual estimate of survival rate for a given lifestage:

(1) Survival = (Estimated Returns) / (Number Released),

where

(2) Estimated Returns = (Number Tags Recovered)/(Tag Recovery Rate).

Because survival rates are typically log-normally distributed, a reasonable comparison would be the annual difference among log-transformed survival estimates:

(3) Difference = log[fry/parr survival] – log[smolt survival]
= log[(fry/parr survival)/(smolt survival)]

Thus, the measure of interest is simply the ratio of fry/parr survival versus smolt survival. Assuming recovery rates are similar for each life-stage for a given year (i.e., recoveries are made during the same spawner survey) the survival ratio estimate is given by:

(4) Ratio = [(# fry/parr tags)/(# fry/parr released)] / [(# smolt tags)/(# smolt released)]

The paired-sample t-test is now seen as a one-sample t-test, where these data consist of annual estimates of log(Ratio). Under the null hypothesis of equal survival rates, the expected value for the mean of the data is log(1) = 0. The one-tailed alternative is that fry/parr survival is less than smolt survival, that is, the mean of the data is less than 0.

Unfortunately, simple analytical formulas for determining the statistical power and precision of estimates are not applicable in this case because there are two sources of variation that need to be accounted, yet they are not easily combined analytically. The first is inter-annual variation in survival rates. The second is sampling error associated with the recovery of tags. If few tags are recovered, the sampling error will be high and estimates poor.

We therefore used simulation analyses to assess statistical power and precision. In brief, the following methods were used:

- Annual numbers of tagged fish (release groups) were assumed to be 20,000 for fry/parr and 4000 for smolts
- Annual survival rates for fry/parr and smolts were generated using log-normal distributions with different combinations for the mean of each distribution (discussed below) and standard deviations of 1.0 for fry/parr and 0.5 for smolts
- Annual tag recoveries for each life stage were generated using Poisson distributions (appropriate for counts of rare events such as tag recoveries) where the mean and variance of a given Poisson distribution were equal to the expected number of tag recoveries (= # tagged * survival rate * recovery rate)
- The recovery rate of tagged spawners was assumed to be 30%
- For a given simulation trial, the simulated tag recoveries were used to estimate annual survival ratios as described above, and a one-sample t-test was used to test the null hypothesis (one-tailed, alpha = 0.05) and estimate the mean of the simulated ratios and the corresponding 95% confidence interval of the mean
- The simulation procedure was repeated 500 times

- Across the 500 trials, statistical power was estimated as the proportion of trials in which the null hypothesis was rejected, and averages were computed for the point estimates and 95% confidence intervals of the mean survival ratio

This simulation procedure was repeated for six combinations of mean survival and duration of the experiment (4, 6, 8, and 10 years). The six combinations for mean survival are shown in Table 2 (i.e., smolt survivals of either 1% or 3%, and fry/parr versus smolt survival ratios of 0.05, 0.10, or 0.25).

Note that several conservative (pessimistic) assumptions were built into the simulations. First, the tag groups were set below the target values (only 4,000 smolts and 20,000 fry/parr were used). Second, the standard deviations for survival rates were set high. For example, the standard deviation of the historic smolt-to-spawner return rates in Table 1 is only 0.25 (for log-transformed data). In contrast, we doubled that value in the simulations, using 0.5. We further assumed variability in fry/parr survival would be considerably higher, and used a large standard deviation of 1.0 for log-transformed survival rates. Finally, we did not include covariation among fry/parr and smolt survival rates across years. Such covariation is expected, and would reduce variation in estimates of survival ratios under the paired design used above. For these reasons, we consider the following results to be pessimistic.

Results

The simulated experiments had high statistical power to detect anticipated differences in fry/parr and smolt survival rates (Table 3). For example, if mean smolt survival was 3% and fry/parr survival was ¼ that of smolts (i.e., fry/parr survival = 0.75%; fry/parr vs. smolt survival ratio = 0.25), the estimated statistical power was 0.570 after 4 years, and 0.796 after six years of experimentation (a value of 0.796 means a 79.6% probability of correctly rejecting the null hypothesis). Interestingly, values of statistical power were also quite high for simulations in which smolt survival was only 1%, and corresponding fry/parr survival was similarly reduced (Table 3). Note the average tag recoveries were quite low in these latter simulations (see Table 2 for expected recovery numbers).

Of course, as fry/parr survival approaches smolt survival, the statistical power to detect differences between them will decrease appreciably. However, if estimates of fry/parr survival were in fact quite large, say ¼ of those of smolts (ratio = 0.25), this would be a remarkable finding and would lead to vast new insight regarding the potential contribution of fry/parr to adult recruitment (currently, few consider fry/parr to be of any real significance). Because fry and parr can comprise a very high fraction (e.g., 80-90%) of out-migrating juveniles in some years (Table 1), even a fry/parr survival rate of $1/10^{th}$ that of smolts (ratio = 0.1) would imply that roughly a third to half the adult recruitment from such a year would be due to the fry/parr life stages. Again, this would be a remarkable finding. Thus, we are not so concerned with the statistical power to detect minor differences between fry/parr and smolt survival rates. Rather, we hope to obtain reasonably precise estimates of the relative survival rates of these different life stages.

Simulated 95% confidence intervals (CI) for the survival-ratio estimates are shown in Table 4. For example, for a mean smolt survival of only 1% and a fry/parr survival ratio of 0.1 (i.e., fry/parr survival = 0.1%), the 95% CI for the survival ratio ranged from 0.028 to 0.385 after 4 years, and from 0.041 to 0.299 after 6 years (Table 4). Interestingly, under the scenario where smolt survival was 3%, and hence tag recoveries were 3 times greater on average for both life stages, confidence intervals were only marginally better (Table 4). Under the simulation conditions we explored, adding more years of data resulted in larger gains in precision than did increasing the number of tag recoveries (Table 4). Thus, given the pessimistic assumptions used in these analyses, it appears even the worst-case scenarios provide meaningful results, and improvements due to additional tag recoveries (i.e., from somewhat larger tag groups) would be minimal.

In general, the 95% CI of simulated estimates in Table 4 suggest meaningful estimates ought to be obtained using the proposed study design. The precision is not outstanding, but it is not discouraging either. It is <u>important</u> to recognize the simulated estimates are based on multi-year averages, and because we incorporated high levels of inter-annual variation in the simulated fry/parr and smolt survival rates, there was considerable variability in actual survival ratios due to "natural" processes rather than sampling error. This natural variation would exist <u>no matter how many fish were tagged and recovered</u>. Thus, it is important to also consider the general precision of each annual estimate. These were <u>much more precise</u> than the multi-year averages. For example, for smolt survival = 1% and a fry/parr survival ratio = 0.1, the simulated 95% CI for a single annual ratio estimate ranged from 0.03 to 0.22. When smolt survival was increased to 3%, the 95% CI ranged from 0.06 to 0.16.

Table 3. Simulated estimates of statistical power for one-tailed t-tests (H0: fry/parr and smolt survival are not different; HA: fry/parr survival is less than smolt survival; Alpha = 0.05) for different combinations of study years and "true" simulated values of the fry/parr versus smolt survival ratio (e.g., ratio = 0.05 means that fry/parr survival equals 0.05 times the smolt survival). See text for details.

Smolt survival = 0.01 (1%)

	Fry/Parr vs. Smolt Survival Ratio		
Years	**0.05**	**0.10**	**0.25**
4	0.854	0.824	0.504
6	0.978	0.974	0.762
8	1.000	0.994	0.864
10	1.000	0.998	0.928

Smolt survival = 0.03 (3%)

	Fry/Parr vs. Smolt Survival Ratio		
Years	**0.05**	**0.10**	**0.25**
4	0.966	0.882	0.570
6	0.998	0.990	0.796
8	1.000	1.000	0.904
10	1.000	1.000	0.954

Table 4. Simulated estimates and 95% confidence intervals for fry/parr vs. smolt survival ratios for different combinations of study years and "true" simulated values of the fry/parr versus smolt survival ratio (e.g., ratio = 0.05 means that fry/parr survival equals 0.05 times the smolt survival). See text for details.

Smolt survival = 0.01 (1%)

	Fry/Parr vs. Smolt Survival Ratio		
Years	**0.05**	**0.10**	**0.25**
4	0.067 (0.013 - 0.254)	0.116 (0.028 - 0.385)	0.262 (0.066 – 0.939)
6	0.065 (0.023 - 0.183)	0.111 (0.041 - 0.299)	0.252 (0.095 – 0.671)
8	0.064 (0.029 - 0.143)	0.114 (0.051 - 0.255)	0.263 (0.119 – 0.582)
10	0.065 (0.033 - 0.129)	0.115 (0.058 - 0.228)	0.265 (0.132 – 0.531)

Smolt survival = 0.03 (3%)

	Fry/Parr vs. Smolt Survival Ratio		
Years	**0.05**	**0.10**	**0.25**
4	0.052 (0.014 - 0.194)	0.101 (0.027 - 0.343)	0.255 (0.072 - 0.803)
6	0.052 (0.020 - 0.133)	0.101 (0.040 - 0.257)	0.255 (0.103 - 0.633)
8	0.052 (0.024 - 0.112)	0.101 (0.046 - 0.220)	0.249 (0.116 - 0.534)
10	0.050 (0.025 - 0.100)	0.098 (0.049 - 0.194)	0.245 (0.125 - 0.481)

Explanation of the Inapplicability of Other CWT Release Programs

It is critical to note tag recovery rates from CWT releases of hatchery smolts in the Stanislaus do not appear to provide reasonable estimates of anticipated tag recoveries. We investigated a previous study plan in which expected tag recoveries were based on results for hatchery CWT releases conducted in 1986, 1988, and 1989 near Oakdale and at the mouth of the Stanislaus River. Those estimates suggested one tag recovery would be expected per 12,000 to 25,000 fish tagged at Oakdale, and one tag recovery per 3,000 to 55,000 fish tagged at Caswell. In contrast, we suggested roughly one tag recovery would be expected per 110 smolts tagged and per 1,100 fry tagged at Caswell. Clearly, there is a huge discrepancy between the hatchery-based estimates and our estimates. If the former were correct, there would be no point to conducting this study even if fish were also tagged at Oakdale. However, it is highly unlikely the hatchery-based estimates are valid.

For example, suppose under the best-case scenario suggested by the hatchery estimates, one tag was recovered during the carcass survey per 3,000 smolts tagged at Caswell. As noted in our proposal, tag recovery rates among spawners can be expected to be 30% (0.3) or better based on recent CDFG carcass recovery estimates. Thus, we would estimate about three adult spawners (=1/0.3) had tags, which implies a smolt-to-adult spawner return rate of 3 adults per 3,000 smolts, that is, 0.1%. Again, this is the best-case scenario. Similarly, we conducted a preliminary analysis of hatchery CWT releases in the Stanislaus during 2003, and determined that the approximate smolt-to-adult spawner return rate of these hatchery releases was also less than 0.1%.

If such an extremely low survival rate was experienced by smolts after passing Caswell, we would expect spawner abundances to be roughly 1/40th of those observed in recent years. In fact, we would expect Stanislaus fall-run Chinook to be functionally extinct within two generations. This apparent discrepancy is likely an artifact of out-of-basin hatchery fish being released in unfamiliar habitat where predation, stress, and migratory disruption result in high mortality rates. Furthermore, a number of the hatchery CWT releases were conducted near Oakdale, thus subjecting fish to additional, potentially substantial, in-river mortality already avoided by wild juveniles passing Caswell. Finally, hatchery CWT releases occur over a narrow time window, which increases the potential a release group will experience episodic periods of high mortality. In contrast, we propose to tag wild juveniles continuously across the migration season, thereby obtaining a reasonably representative sample of the juvenile population and the migration conditions they will experience.

Last, survival indices and tag recovery rates from other CWT studies such as those conducted in the Mokelumne and Feather Rivers were investigated, but these were also found to have a number of limitations. Again, these studies are not comparable to our proposed study because results for hatchery releases are likely to be negatively influenced by poor juvenile survival and high straying rates. In contrast, survival rates of wild fish passing Caswell are estimated to be high (up to 3% or greater; discussed below) and tag recovery rates from returning tagged adult spawners can be expected to be 30% or better (based on recent CDFG carcass recovery estimates).

Comment: Limited number of tag codes will only allow distinction between smolts versus fry/parr.

Response:
Fry and Parr will be separately tagged with half-length Decimal Coded Wire Tags™ (CWT) consisting of at least 18 unique batch codes. Batch codes will be changed every 7 days or every 2,000 marked fish, whichever comes first in February and March. Fry and parr batch codes will be changed every 10 days or every 2,000 marked fish, whichever comes first, for the remainder of the tagging season. By marking small groups of fish, CFS will be able to distinguish recoveries based on a limited time period of emigration. Differential contribution rates of the fry and parr life history types will be distinguishable and related to the environmental conditions during that migration period. Batch codes will also change annually.

Smolt migrants will be marked with full-length sequential tags. These tags will give each fish a unique mark and, relative to batch codes, allow for a more robust statistical interpretation of relationships between migration period, fish size, and environmental conditions. The design of this study allows us to determine the contribution rate of various life history types (fry, parr and smolt migrants) to the returning adult population and draw conclusions about the effects of a variety of environmental conditions (e.g., instream flow, turbidity, etc.) on contribution rate.

Comments: Fish will only be tagged at Caswell, but need to be also tagged at Oakdale in order to obtain minimal sample sizes.

Response: As discussed above, the Caswell traps should provide large enough sample sizes to yield meaningful study results. Moreover, this study is focused on overall survival and the contribution of life history types (fry, parr and smolt outmigrants) to the returning adult population, and is not intended to provide river segment specific survival estimates.

Three traps have operated on the Stanislaus River since 1996: One at Oakdale, and two at Caswell. To meet out tagging objectives, we have added a third trap in the lower river near Caswell. Based on catch rate data from rotary screw trap operations at Caswell, minimum sample sizes are likely to be met by the three traps operating at this lower site.

In light of the study objectives, it is logical to mark and release migrants as low in the river as possible. An important assumption for this study is fish captured at the Caswell traps are emigrating out of the river. We believe this assumption to be valid for Caswell, but it may not apply to fish captured at Oakdale. Fry and parr tagged at Oakdale may have significant instream residence time before emigrating from the system (i.e. fry/parr tagged at Oakdale may not actually leave the system until they smolt) obscuring the ability to determine their outmigrating life stage upon tag recovery. We recognize tagging fish at Oakdale could help maximize the effectiveness of this study in future years by increasing sample size. However, further discussions are needed to determine the most effective way to accomplish this effort. We propose to continue to work cooperatively with Stanislaus River stakeholders to explore opportunities to expand the scope of this study.

Comment: Potential introduction of additional and unnecessary variables associated with different capture methods.

Response: The objective of this study is to determine the relative contribution rates of juvenile Chinook salmon fry, parr and smolt life history types to the returning adult population. To meet this objective as many juvenile Chinook as possible need to be marked in the lower river to avoid in-river mortality issues (as discussed previously) and provide enough fish for suitable recoveries. CFS has installed a third trap at Caswell to increase the numbers of fish collected for tagging and we anticipate suitable numbers of tagging fish will be supplied by these three rotary screw traps (as discussed previously). Additional collection methods are not being evaluated at this time.